Science learning and graphic symbols: an exploration of early years teachers' views and use of graphic symbols when teaching science

Eurasia Journal of Mathematics, Science & Technology Education, 2016, **12**(9), 2399-2417
doi: 10.12973/eurasia.2016.1275a

Science Learning and Graphic Symbols: An Exploration of Early Years Teachers' Views And Use of Graphic Symbols When Teaching Science

Maria Kambouri
University of Reading, U.K.
Eliada Salowm Pampoulou
Special Educational Solutions, CYPRUS
Myria Pieridou
The Open University, U.K.
Michael Allen
Kingston University, U.K.

•*Received 22 December 2015*•*Revised 18 January 2016* •*Accepted 5 February 2016*

The study investigated early years teachers' understanding and use of graphic symbols, defined as the visual representation(s) used to communicate one or more "linguistic" concepts, which can be used to facilitate science learning. The study was conducted in Cyprus where six early years teachers were observed and interviewed. The results indicate that the teachers had a good understanding of the role of symbols, but demonstrated a lack of understanding in regards to graphic symbols specifically. None of the teachers employed them in their observed science lesson, although some of them claimed that they did so. Findings suggest a gap in participants' acquaintance with the terminology regarding different types of symbols and a lack of awareness about the use and availability of graphic symbols for the support of learning. There is a need to inform and train early years teachers about graphic symbols and their potential applications in supporting children's learning.

Keywords: early years education, graphic symbols, inclusive practice, science education, teaching.

INTRODUCTION

Children's development of scientific thinking and their ability to communicate are closely linked with the experiences gained from their environment and their

Correspondence: Maria Kambouri,
University of Reading, Institute of Education, London Road Campus 4 Redlands Road, Berks RG1 5EX Reading, U.K.,
E-mail: m.kambouri@reading.ac.uk

everyday activities (Johnston, 2005; Gomez-Arizaga, Bahar, Maker, Zimmerman & Pease, 2015). Furthermore, difficulties in communication and lack of vocabulary can
be an obstacle for science learning (Cohen & Kagan, 1979; Fragkiadaki & Ravanis, 2015; Johnston, 2005; Kambouri, 2015; Russell & Watt, 1992). Supporting the clear understanding of the language used in science can help bridge the gap between the language of the science content and the language and background knowledge that children bring to the class (Song & Carheden, 2014; Young, 2005).

As demonstrated in the following sections, graphic symbols with linguistic characteristics can support language and communication when delivering the mainstream curriculum, including science. However, they are usually used solely to support children with special educational needs and disabilities and there is very little is known about the use of these types of symbols in mainstream schools and even less is known for the case of Cyprus (Mavrou, 2011; Mavrou et al., 2013; Pampoulou & Abbott, 2013; Pampoulou & Angelides, 2012). This paper aims to address that gap by exploring early years teachers' understanding of graphic symbols in mainstream settings and to identify their use when delivering inclusive science lessons in that context.

To support this investigation the paper follows an interpretivist approach of understanding phenomena that occur in natural settings, such as classrooms, through the exploration of qualitative data, with the aim of incorporating participants' views, values and experiences (de Villiers, 2005) into the findings. This is based on the assumption that knowledge is achieved through social constructions such as language, consciousness, and shared meanings (Baskerville, Kaul & Storey, 2015; Klein & Myers, 1999; Kim & Yoon, 2016). Thus, the aim of this study is to develop an understanding of the social context of the phenomenon under investigation and the ways in which the phenomenon influences and is influenced by the social context (Walsham, 1995).

Visual symbols are commonly used in everyday life, from instructions on a household appliance to signs in airports and they can give instant information which may otherwise be difficult or time-consuming to access (Abbott, Detheridge & Detheridge, 2006; Danos, 2014). For example, a road sign in text would be useless for someone who could not read the language and would take more time to read, which could be dangerous when driving. In academia, the term symbol is used in many different disciplines, such as in psychology and education, as well as in Augmentative and Alternative Communication (AAC), that specialises in supporting people with little or no functional speech to communicate (Glennen & DeCoste, 1997). This results in a range of definitions and usages of the term (Abbott et al., 2006; Beukelman & Mirenda, 2013; Pampoulou & Detheridge, 2007; Peirce, 1931; Venkatakiri, 2002), which are discussed below.

State of the literature

- Teaching science and science vocabulary can be challenging for early years children, who sometimes struggle to communicate effectively; this creates an obstacle for science learning.
- Previous research indicates that graphic symbols can support vocabulary learning and communication. However, previous research has mostly focused on older learners or on children with special educational needs and disabilities.
- Current literature suggests the need to investigate mainstream teachers' familiarity and use of graphic symbols when delivering the curriculum.

Contribution of this paper to the literature

- This study investigates the use of symbols in early years as an alternative tool for delivering science in mainstream kindergartens, instead of focusing on children with special educational needs and disabilities as previous research has done.
- The study focuses on the teachers and their understanding of what symbols are, which will help identify teachers' needs and thus suggest appropriate interventions and training to support them in delivering science in the early years.
- The manuscript provides information that will encourage teachers to reflect and evaluate their everyday values and practices; the study has implications for practical applications.

REVIEW OF DEFINITIONS

This study relates to both the discipline of AAC, as the type of visual symbols that this paper focuses on were traditionally used there, and to educational settings, as the research was conducted in early years schools in Cyprus. It is therefore considered appropriate to refer to the literature related to both fields in establishing the terminology for this paper. Within the AAC discipline, different tools (including symbols) and approaches are utilised by professionals to support people who find it difficult or are unable to communicate verbally (Glennen & DeCoste, 1997). Symbols can be divided into two broad types: Within visual and spoken, with the difference between the two lying in the modality through which the meaning is conveyed, namely either visual or auditory (Fristoe & Lloyd, 1979; Lloyd & Blischak, 1992; Lloyd, 1985). With regards to visual symbols, these can be either manual (such as sign-language or nodding/shaking of the head to indicate, for example, yes or no) or graphic. In relation to the latter, under the AAC lens these can be photographs, pictures, illustrations and also the commercially available graphic symbol sets, such as the Picture Communication Symbols, Makaton or Widgit graphic symbols (Beukelman & Mirenda, 2013; Lloyd, Fuller & Arvidson, 1997).

One of the main differences found between photographs, pictures, illustrations and the published graphic symbol (e.g. Makaton) is that the lattermost are systematically designed and provided in sets in order to be used with people who need additional support in terms of communication, accessibility and learning. With regards to these sets, Pampoulou and Detheridge (2007) noted that some commercially available graphic symbol sets have been created "to serve communication purposes and can be used on a personal level such as communication passports, communication boards/books as well as on voice output communication aids (VOCAs)" (p. 21-22). Other commercial symbol sets have been created "to serve literacy purposes and can be used for reading materials, writing activities and accessing the web. Symbols can also exist in a person's environment aiming to make their surroundings more accessible" (Pampoulou & Detheridge, 2007, p. 21-22).

As Abbott et al. (2006, p. 3) also commented, "illustrations give different types of information from symbols [commercially available graphic symbols]" in that they are generally used to convey information, such as procedures or actions, whereas most of the commercially available symbol sets provide information related to language and thus, are better for "constructing graphic supported text, or for a disabled person learning to write". Importantly, one example of these graphic symbols is shown in Figure 1, from the Widgit set (Widgit Symbols, 2015), the type of symbols on which this study focuses; it can be seen that most of the words in the sentence (e.g. sun, evaporate, earth, rain and water) have been replaced with these symbols.

In this paper it is considered that photographs, pictures and illustrations differ from the commercially available graphic symbol sets (from now referred to using the term *graphic symbols*). For instance, as it can be seen in the figure below (Figure 2), concepts that hold a dynamic meaning (such as the process of evaporation and condensation) can be visually presented to children via graphic symbols that were purposively designed to represent language and in this way to carry dynamically not only the meaning of each concept, but also the relation between them (Blau, 1987; Pampoulou & Angelides, 2012; Pampoulou & Detheridge, 2007; Pampoulou, 2015). As explained in the following section, graphic symbols can be useful tools for younger learners and also pupils with disabilities (Detheridge & Detheridge, 2002; Wellington & Wellington, 2002; Pampoulou & Detheridge, 2007).

SCIENCE LEARNING AND GRAPHIC SYMBOLS

The ability to communicate is an essential life skill for all children and young people and is a very important aspect when learning science; however lack of vocabulary and language issues can make communication very hard for children (Kersner & Wright, 2012; Russell & Watt, 1992). For the case of science learning, evidence suggests that children often struggle to communicate their thinking because of their lack of vocabulary (Johnston, 2005; Ntalakoura & Ravanis, 2014;). Similarly, children may not understand the scientific concept in the way it was intended in the communication or they might understand the intended concept but the particular context may suggest a different interpretation of the concept.

The above challenges are directly linked to vocabulary and communication issues which have been identified as one of the main obstacles for science learning and a common source of scientific misconceptions (Allen, 2014; Cohen & Kagan, 1979;

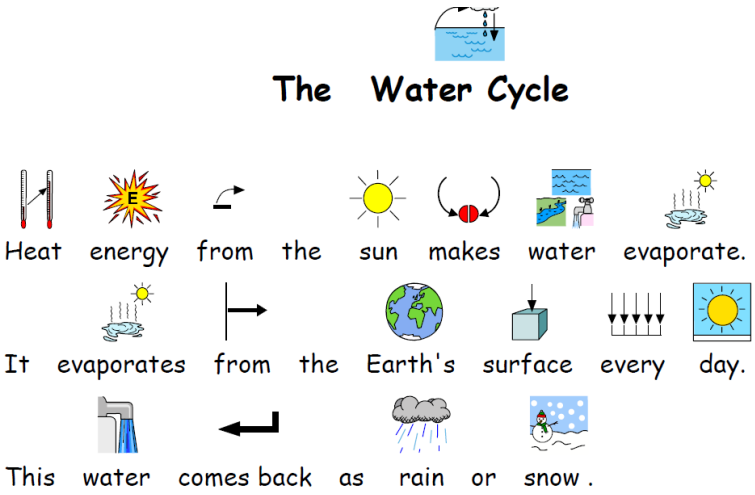

Figure 1. An example of the use of graphic symbols to interpret the Water Cycle (©Widgit Software, 2013; permission granted)

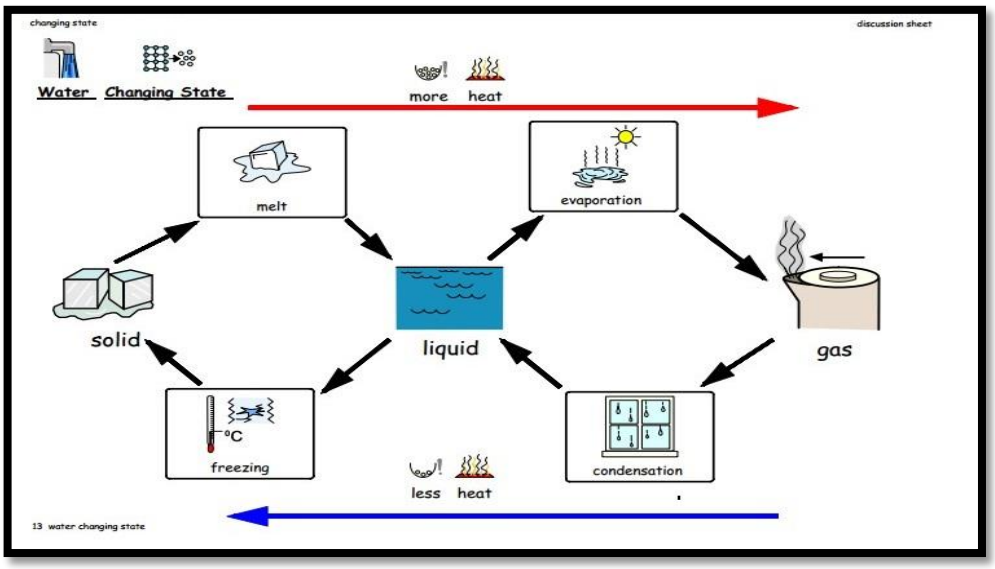

Figure 2. Concepts that hold a dynamic meaning: an example of the process of evaporation and condensation. (©Widgit Software, 2013; permission granted)

Hanuscin, 2001; Kambouri, 2015; Russell & Watt, 1992). This is important for science teaching all over the world, since worldwide research has shown that children from different countries, cultures, educational systems and languages have common informal ways of modelling and understanding phenomena which are linked to language and communication (Allen, 2014; Driver, Asoko, Leach, Mortimer, & Scott, 1994; Kambouri, 2015). Thus, supporting language and communication can greatly benefit the acquisition of science.

One way to do this is by presenting activities in different modes (such as visual, verbal and kinaesthetic), which can support learners with different language levels and vocabulary skills (Sheehy, Rix, Fletcher-Campbell, Crisp & Harper, 2013; Young, 2005). Graphic symbols can be a useful tool when developing such activities, since previous research has shown that they can support children's communication, help with language development and enable them to clarify their understanding (Chalarampous, 2012; Mavrou et al., 2013; Crosskey& Vance, 2011; John and Vance, 2014; Pampoulou & Detheridge, 2007; Wellington & Stackhouse, 2011). Graphic symbols can be used for a multitude of educational purposes, such as signposting the environment, as an aid during story-telling time and as visual timetables for individual children or for the whole class (Greenstock & Pampoulou, 2010; Greenstock & Wright, 2011). They can also be used to support children's listening in class (Crosskey & Vance, 2011), to facilitate reading and writing skills (Abbott, 2000; Lacey et al., 2007; Pampoulou & Detheridge, 2007; Pampoulou, 2015) and to support new or unknown vocabulary (Abbott, 2000; Bondy & Frost, 1994; John & Vance, 2014; Mirenda, 2003; Wellington & Stackhouse, 2011), which is of particular interest for science learning.

Regarding science, Wellington and Wellington (2002) suggested that graphic symbols can be used to help children visualise the meanings of words and thus, be able to understand science concepts. That is, they have the capacity to communicate concepts that are difficult to understand through words by providing visual prompts in symbolic form, such as for 'evaporation' or 'power' (Wellington & Wellington, 2002). Furthermore, because of technological advancement and the fact that interactive whiteboards have been placed in most schools in Cyprus, nowadays graphic symbols can be more easily implemented and used as part of the lesson in a classroom than previously (Callaghan, 2000; Chetwynd, 2008; Murcia, 2014; Vrasidas & Glass, 2005).

Despite their many possible uses, graphic symbols have most commonly been utilised in special schools, or alternately special units placed in mainstream classrooms, mainly to help children that have been designated as having SEN (Pampoulou & Angelides, 2012; Pampoulou, 2015). After the UNESCO Salamanca Declaration in 1994, however, inclusion was placed on the educational agenda worldwide (Vislie, 2003) and the right of all children to mainstream education, regardless of their gender, disability, race, or socio-cultural status, was promoted (Armstrong, Armstrong & Spandagou, 2011). Inclusive pedagogy and practice therefore necessitates the use of a variety of techniques, including graphic symbols, in order to accommodate the needs of all learners. The above, in addition to the importance of supporting language and communication to facilitate the acquisition of science, indicate the significance of this study.

THE STUDY'S CONTEXT

This study focused on the teaching of science by early years teachers in Cyprus, therefore it is considered appropriate to present the context in which the study was conducted. In Cyprus, children with disabilities were traditionally placed in segregated settings, a process that began in 1929 with the establishment of the School for the Blind and numerous other special schools and institutions (Phtiaka,

2007). This form of segregation remained in place until the unofficial practice of integration in the early 1980s, when children were placed in mainstream educational environments through the organisation of special education settings within them (Symeonidou & Phtiaka, 2012). Integration was passed into law in 1999, with the Education Act for Children with Special Needs (113(I)/99), which has a rhetoric of accessibility, equal rights and opportunities for all. Critiques of the law indicated that its content proposes discriminatory practices, which allow for the perpetuation of the dyadic educational system, special and the mainstream, thereby permitting the latter to remain unaltered in terms of culture and pedagogy (Pieridou, 2013). This, often, leaves special teachers responsible for children identified as having special educational needs, while the mainstream teachers' role in both pre-primary and primary settings remains unchanged; mainly due to the absence of in-service teacher education training programmes on inclusion and appropriate teaching techniques for a diverse learner population (Pieridou, 2013; Symeonidou & Phtiaka, 2012).

Similarly to the 113(I)/99 Law, the New National Curriculum (NNC) in Cyprus recognises and values the concept of diversity, reaffirming the government's commitment to the right of all children to an education appropriate to their specific needs (MoEC, 2008a; UNESCO 2009). The NNC was updated in 2010, after fifteen years of unchanged curricula, and finally came into practice in schools in 2012. The NNC is based on the idea that children learn through exploring, playing, debating and participating actively in the process of constructing experiences (Loizou & Papademetri-Kachrimani, 2011). In the new curriculum, learning refers to the overall development of all children, a process that should start from what children already know and aim to develop each child's understanding based on his/her capabilities. Within this context, this paper supports the use of graphic symbols for the benefit of all children, and not as a 'special education' technique.

Focusing on science specifically, this is seen as being a part of young children's holistic development, a means to satisfy their need for experimentation, play and pro-active participation together with their peers (Kambouri, 2015). The NCC highlights the importance of early years in developing children's scientific literacy through skill cultivating activities, children should come in contact with a variety of concepts and gain rich and varied experiences which will support the development of conceptual understanding (Loizou and Papademetri-Kachrimani, 2011; Philippou, Papademetri-Kachrimani & Louca, 2015). It has been recommended that each child leaving the early years phase should have cultivated the scientific skills and language that form the basis of science literacy, such as problem solving, observation and simple inference making (Kambouri, 2015; Loizou & Papademetri-Kachrimani, 2011).

THE USE OF GRAPHIC SYMBOLS IN THE CYPRIOT CONTEXT

The use of graphic symbols as a means to support learners has been recognised in Cyprus by the Ministry of Education and Culture (MoEC), which has installed SymWriter software in all primary (mainstream and special) schools since 2008. According to the ministry's website and the official document sent out to inform schools about this software, the aim is to use it to support children who have difficulties in writing and communication (MoEC, 2012; MoEC, 2014). As suggested in the guidelines shared with schools by the MoEC, the automatic symbolism of each word with the corresponding symbol helps comprehension, develops vocabulary, supports self-correction of the written text, improves written expression and enhances communication for children of all ages, including early years (MK Prosopsis Ltd cited by the MoEC, 2012). As a result, early years teachers have the option to employ graphic symbols along with other teaching methods when teaching

different subjects. This can be done not only by incorporating advanced technologies, such as graphic symbols software in lesson delivery, but also through less advanced ones, such as printed graphic symbols as flashcards, visual timetables, or, as shown in Figure 1, a leaflet that visually displays the process of the water cycle.

Charalambous (2012) evaluated the use of graphic symbols (through SymWriter) in early years settings in Cyprus in order to establish their effect on children's questioning skills. The study involved 40 children (3.5 – 5 years old) who were randomly divided into two groups. The researcher used a pre and post-test to identify the level of the children before and after the interventions. The results indicate a statistically significant difference between pre and post-test answers ($p<0.05$); this led the author to conclude that using SymWriter facilitates the development of questioning skills in children (Charalambous, 2012). This improvement is supported by the notion that visualisation helps children to remember better and recall meaning more easily (Acha, 2009; Mayer, 1997; Pampoulou & Detheridge, 2007).

There are a few research studies that have focused on the use of commercially available graphic symbols in Cyprus, but none has investigated their implementation in science lessons during the early or later years of schooling (Mavrou, 2011; Mavrou et al., 2013; Pampoulou & Abbott, 2013; Pampoulou & Angelides, 2012). Mavrou and her colleagues (2013) focused on the clinical implementation of graphic symbols in pursuing language skills and language development in mainstream schools, while studies by Pampoulou & Abbott (2013) Pampoulou & Angelides (2012) explored professionals' experiences of using graphic symbols in inclusive primary schools in England and Cyprus. Owing to the scant research relating to the implementation of graphic symbols that are commercially available (Charalampous, 2012; Pampoulou & Angelides, 2012), the current research study aims to investigate the experiences and views of early years teachers regarding the use of graphic symbols in mainstream early years classrooms while teaching science.

RESEARCH AIM AND QUESTIONS

The aim is to explore mainstream early years teachers' views of symbols, and their familiarity with graphic symbols specifically, and also to elicit the ways in which this group of teachers use graphic symbols when teaching science to young children. It has been recognised that this is an under-investigated area which requires further attention (Charalampous, 2012; Pampoulou & Angelides, 2012); this study aimed to shed some light on this area by addressing the following questions:

1. What are early years teachers' views of symbols and their usefulness?
2. Are these teachers familiar with graphic symbols specifically?
3. Do they use graphic symbols while teaching science, and if so, in which ways?

In addressing these questions we identify early years teachers' current knowledge and practice about graphic symbols, which enables us to address and cover the gap in the research literature and to make recommendations that can help improve science teaching in early years classrooms.

RESEARCH METHODOLOGY

An exploratory case study was carried out, focusing on the case of Cypriot early years teachers, which included lesson observations and interviews. Specifically, six lessons each taught by a different early years teachers were observed; the same teachers were interviewed to discuss practice as well as their understanding and

views of the usefulness and applications of graphic symbols. Thus, the methodology adopted was able to provide rich data on the focal subject matter by focusing on social constructions such as language, perceptions and shared meanings (Gerring, 2007; Klein & Myers, 1999).

Participants

The participants of the study were selected from a list of all public mainstream early years schools in Cyprus provided by the MoEC, all of which are required to provide an inclusive provision and practice. Six schools were randomly selected and invited to participate in the study; three were based in Nicosia and three in Larnaca. The participants selected were six early years teachers, all of whom were women. The teachers' mean of years of experiences was 9.4 years, their highest qualification was a bachelor degree in pre-primary education (or equivalent) from a Cypriot higher education institution.

The average number of children in the participating classrooms was 22, with a total number of 132 children. The mean of the children's age was 4.3 years and 10% of all the children involved were designated as having special educational needs (with at least one child in each classroom). Specifically, the children identified as having special educational needs via the official processes of the Ministry of Education and Culture consisted of the following: two children had dyslexia, three children had autism, two more children had behavioural emotional and social difficulties (BESD), there were two children with speech and language disorder and three more children with attention deficit hyperactivity disorder (ADHD).

Research tools and data collection

The case study design included the use of observations and interviews. Observations were employed to follow the multitude of events that take place in an early years classroom. That is, they helped in the collecting of information on what actually goes on during teaching and learning (Simpson & Tuson, 2003; Wragg, 1994). For the purposes of data collection, all the teachers who participated were asked to consent to be observed teaching the same topic to allow for direct comparisons to be made (Gerring, 2007), and were asked to suggest a topic that they would prefer teaching. Luckily enough all teachers mentioned that they could teach something relevant to the weather. This was probably because the data collection took place in the autumn when owing to this being a time of rain after a long dry summer, early years teachers usually teach this topic. As a result the six teachers (participants) agreed to be observed during their teaching of the water cycle phenomenon as this was in accord with their original teaching plans.

It is important to note that the participants were specifically asked to teach the topic in the same way as they would normally do, since this would help in producing a naturalistic study and so promoting the validity of the data. The lessons were planned solely by the teachers without any involvement by the researcher, as her role was only that of an observer. Each lesson lasted for approximately 40 minutes and an audio recorder was used to capture the voices of the children and their teacher *ad verbatim*. The lead researcher was also provided with the lesson plan in advance, which helped her to follow the lesson objectives and the activities that the teacher was intending to carry out, putting classroom events into context both during the lessons and when analysing the data. She took field notes during the observations and recorded any use of all types of symbols. This helped to develop a general understanding of the symbols used by teachers and to facilitate the interview discussions.

The interviews were conducted with each teacher within a period of three days after the completion of each lesson observation. The aim was to allow each teacher

to explain or clarify any issues and also to elicit her understanding of the use of graphic symbols for teaching, which subsequently allowed the research team to appreciate events from the teachers' perspectives (Silverman, 2000). The interviews were semi-structured and lasted for approximately twenty minutes each. More specifically, they were developed around the following questions: 1) What does the term 'symbol' mean to you? 2) Are you familiar with the term 'graphic symbols' and if yes how would you define it? 3) Do you use graphic symbols while teaching science, and if yes, how do you employ them? The teachers were encouraged to use examples when explaining their views and when possible relate these to the observed lesson observed.

Ethical considerations

The study followed the BERA (2011) ethical guidelines and the EECERA Ethical Code for Early Childhood Researchers (2014) was adhered to. Moreover, permission to conduct the research was granted first by the MoEC in Cyprus and then by the headteacher and the parents who agreed to give their informed consent for the lesson observations. The children were also informed about the aim of the study and they were aware that the focus was on their teacher and not them. The teachers and the children were informed of their rights for privacy, anonymity and confidentiality and also of their right to withdraw at any time, but all of them gave their consent to participate.

Data analysis

The qualitative data collected during both the interviews and the observations were analysed with the use of QSR NVivo 9 and using the thematic approach (Bogdan & Biklen, 2007), which helped to identify, analyse and report themes within the data, in depth (Braun & Clarke, 2006).

Careful analysis of the interviews enabled the identification of themes, through words and phrases that were repeated during the discussions. The repetition of similar ideas implies that there are similarities between teachers' views of graphic symbols and their implementation when teaching early years science; these are presented below. Themes deriving from the observations were then compared to those arising from the interviews to triangulate data, which increases the validity (Hall, 2008). In addition, following the interpretive approach the study takes into account the relationship between the researcher and what is being explored, the researcher is seen an instrument for interpreting data which might lead to subjective findings (de Villiers, 2005). However, this is considered to be the appropriate approach for studies focusing on social phenomena and behaviour, such as this one (de Villiers, 2005; Leedy & Ormrod, 2001).

Considering the above, any conclusions deriving from this study are to be treated as tentative. Recognising some additional limitations of this study, such as the small number of participants and duration of the study, it is acknowledged that the outcomes might not be representative of the general situation in Cypriot early years schools. Hence, further research is required to extend this line of inquiry by using larger samples of teachers and children, as well, in such way that will help understand the impact that employing graphic symbols can have on children's learning and development.

RESULTS AND DISCUSSION

The methods used provided rich data, the results of which are presented here in order to address the research questions under investigation. As already mentioned, the teachers were observed when teaching the water cycle in their usual way and they were also asked to provide their own definition for graphic symbols and

examples of how they use them for the teaching of science. To facilitate the data presentation, Table 1 provides a summary of the data collected during the observations, whereas Table 2 presents some of the key statements the participants made during the interviews.

Teachers' views on symbols

During the interviews, the teachers were asked to explain their opinions of what symbols are and their usefulness, with results revealing some similarities in their views. For instance, all the participants agreed that using symbols in the early years can help children develop their communication skills, language and understanding. Teacher 1 highlighted the key role of symbols in the early years when working with children who are still developing their reading skills: 'Symbols are the initial stage prior to reading so we use symbols to communicate and understand each other'. Likewise, teacher 2 pointed out symbols' key role during early years in relation to reading. As she said, using symbols can help prepare children for reading, in that 'they can help children communicate at a stage in which they have not yet fully developed their reading and writing skills'.

Teacher 4 also pointed out that symbols are a big part of our everyday environment: 'From letters up to numbers and musical notes, we use symbols for convenience, it's easy.' She also suggested that early years teachers should symbols to help children develop their pre-reading skills, agreeing with teacher 2 and 1. As she explained, symbols can support children's understanding and prepare them for reading since 'symbols work as codes, just like letters and numbers do. Each symbol

Table 1. A summary for each lesson with reference to the use of graphic symbol

	Summary of lesson	**Use of Graphic Symbols**
Lesson/ Teacher 1	Picture of river with trees around - Discussion: use and need of water. The teacher demonstrated an experiment supported by a picture used to represent objects (e.g. pan) to explain the experiment – Discussion. Experiment: boiling water – vapour - cold plate – water drops- discussion	The teacher suggested that she used graphic symbols to illustrate the experiment. The researcher noted the use of pictures and arrows to replace words like clouds, see and sun.
Lesson/ Teacher 2	Story Telling: Rain last night (sound of raining), Song: 'Rain', Fairy tale about the trip of a rain drop, role play to recall events from the story. Use of book pictures	The teacher did not claim any use of graphic symbols during the lesson. The researcher agreed.
Lesson/ Teacher 3	Problem Solving: A frog lost its lake, Where has it gone? Song: 'Cloud', Tea for our guest - vapour from kettle - Where else do we see steam? – List of ideas (e.g. bathroom, windows). Storytelling: 'The journey of a water drop'	The teacher did not claim any use of graphic symbols during the lesson. The researcher agreed.
Lesson/ Teacher 4	Storytelling: a water drop is going on a trip and her mum said that she will evaporate - what is vapour? Give examples. Continue the story – summarise – role play to recall events from the story – Worksheet: Colour the pictures based on our story. The worksheet was developed by the teacher to evaluate children's understanding at the end of the lesson.	The teacher suggested that the worksheet she developed by replacing words with pictures was an example of using graphic symbols. The researcher noted the use of pictures and arrows to replace words like clouds, see and sun.
Lesson/ Teacher 5	Young scientists, Storytelling based on a previous activity of observed the sky (children lied on the floor looking at the sky and talked about what they saw) - connection: where do clouds find rain? List of ideas, Teacher experiment demonstration: boiling water in kettle – vapour – water drops collected on cold plate (on top of the kettle) connection with water in the sea and sun boiling it.	The teacher did not claim any use of graphic symbols during the lesson. The researcher agreed.
Lesson/ Teacher 6	Storytelling: 'The feathered cloud" – The teacher puts pictures in a *circle* during storytelling to make connection to water *cycle*. To summarise – children recall the story – teacher emphasises: 'This circle goes on and on forever', Discussion about colours of clouds – Children draw a picture based on the story (evaluation)	The teacher suggested that she used graphic symbols to replace all words when describing the 'Water Cycle'. The researcher noted the use of pictures and arrows to demonstrate the series of events taking place during the 'Water Cycle' phenomenon.

is a code accepted by everybody and it helps children feel confident when communicating'.

Additionally, teacher 5 highlighted the importance of symbols in everyday life suggesting that symbols can help 'save time and simultaneously to be able to communicate effectively with other people', something also suggested by Abbott, Detheridge and Detheridge (2006). As the teacher explained a symbol may contain many messages that one might not be able to 'express in words'. Likewise, teacher 3 shared the understanding that symbols are used to represent something else 'like mathematical symbols, for example numbers represent quantity, or an arrow represents some kind of relationship.' Teacher 6 had a similar understanding and viewed symbols as an alternative way to communicate. As she said symbols are 'a form of knowledge representation, and it's a faster way to communicate'.

In addition, both teacher 1 and teacher 4 agreed that the use of symbols facilitates providing clear explanations to children about abstract scientific concepts that are difficult to understand when only using words. In agreement with Johnston (2005), teacher 6 suggested that for early years children communicating effectively can be a challenge 'especially now that we have a lot of children in our classes whose first language is not Greek, some of whome do not speak Greek at all'. As she explained, symbols can help teachers bridge the communication gap and 'communicate with children more effectively and can make children feel more comfortable and confident'. This is also supported by Abbott and Lucey (2005) and

Table 2. Teachers' understanding of symbols and their definitions for graphic symbol

Teachers	Teachers'a Understanding
Teacher 1	Symbols play a key role in early years because children do not know how to read. Symbols are the initial stage prior to reading so we use symbols to communicate and understand each other on various issues at school. Definition: *Graphic symbols are the symbols that specifically use a graphical representation.*
Teacher 2	Symbols can help teachers prepare children for reading and play a key role during a child's early years, since they can help children communicate at a stage in which they have not yet fully developed their reading and writing skills. Definition: No definition provided.
Teacher 3	A symbol is something that can be used to represent something else, like a word or a concept. Like mathematical symbols, for example numbers represent quantity, or an arrow represents some kind of relationship. Symbols in general have an educational value since they help teachers to explain abstract concepts or problems and also to clarify differaent issues. On the other hand, graphic symbols help children to see relationships or patterns that are not easy to understand with words. That is why I usually use graphic symbols when teaching mathematics or science. Definition: *Graphic symbols are the symbols that help children understand the data given, for example for a problematic situation that they have to solve, using a graphical representation.*
Teacher 4	Symbols can be found everywhere around us and are part of our lives. From letters up to numbers and musical notes, we use symbols for convenience, it's easy. Thus, early years education should familiarise children with using symbols to prepare them. I use symbols because I believe that they support children's understanding and they also prepare children for reading by practising their pre-reading skills. That is because symbols work as codes, just like letters and numbers do. Each symbol is a code accepted by everybody and it helps children feel confident when communicating'. Definition: *Graphic symbols are symbols that use graphics, like arrows and pictures, to represent something else.*
Teacher 5	Symbols are an important element in our lives, since we use them to save time and simultaneously to be able to communicate effectively with other people. A symbol can contain many messages that you cannot express in words. Definition: No definition provided.
Teacher 6	Words can be very confusing for children. Especially now that we have a lot of children in our classes whose first language is not Greek, some of which do not speak Greek at all. Symbols can help us communicate with children more effectively and can make children feel more comfortable and confident. Symbols are a whole language, it's a form of knowledge representation, and it's a faster way to communicate. Definition: 'G*raphic symbols' is a type of symbols that can help children to empower their reading and writing skills and feel more confident when communicating.* For science, I usually introduce graphic symbols at the beginning of the year, when we talk about the weather and we use pictures to symbolise different weather condition and to make predictions.

Chetwynd (2008) when referring to children in special schools.

In sum, the results indicate that all the focal teachers considered symbols to be an important element in children's lives and they felt that they should help their pupils familiarise themselves with them. They also supported the perspective that symbols can help children in the development of their reading and writing skills, while also fostering their scientific understanding, which is in accordance with the MoEC's report (2012). The above responses reflect these teachers' general understanding of symbols, but not specifically their understanding of graphic symbols, which is discussed in the next section.

Issues regarding graphic symbols' terminology

During the interviews, participants were also asked to give their own definition for graphic symbols, something which led to one of the key findings for this study, which is that early years teachers might not yet clearly comprehend the term graphic symbols. When responding to this question only teachers 1, 3, 4 and 6 provided a definition for graphic symbols whereas teachers 2 and 5 responded that they were not entirely familiar with the term and thus unable to provide a definition for it.

Specifically, teacher 1 defined graphic symbols as those symbols 'that specifically use a graphical representation', which is a rather general definition when compared to those reviewed in the literature. When asked to give an example she referred to the picture that she had used during the observed lesson (Figure 2). Similarly, teacher 4 defined graphic symbols as 'the symbols that use graphics, like arrows and pictures, to represent something else' and when asked to provide an example she referred to the worksheet she used in the observed lesson. Based on the literature, both of these examples are considered to be graphic symbols since they have not been developed as part of a systematically designed set (Beukelman & Mirenda, 2013; Lloyd, Fuller & Arvidson, 1997). These results suggest a possible misinterpretation of the term graphic symbols from both teachers.

Teacher 3 stated that graphic symbols can support children to recognise patterns that would not have otherwise been clearly understood. As she added, she uses graphic symbols when teaching mathematics and science. However, when asked to give an example she was unable to offer a specific one from her own practice. She defined graphic symbols as 'the symbols that help children understand the data given, for example for a problematic situation that they have to solve using, a graphical representation'. This definition is more specific than the one provided by teacher 1, but still fails to demonstrate that graphic symbols are purposely designed to represent specific aspects of language (Pampoulou & Detheridge, 2007).

Finally, teacher 6 also appeared to be confused about the terminology of graphic symbols. During the interview she mentioned that she uses graphic symbols throughout the year to introduce children to scientific concepts. She defined them as 'the type of symbols that can help children to empower their reading and writing skills and feel more confident when communicating'. Nevertheless, when asked to provide an example, she gave the rather muddled response: 'all different types of graphic symbols that can be useful for my children, such as photographs and pictures from the internet'.

The findings indicate that the participants perceived 'graphic symbols' as concerning, in broad terms, pictures and photographs, but they did not differentiate the commercially available graphic symbols (such as the Picture Communication Symbols (PCS), Makaton and Widgit sets) from other types. That is, none of the participants referred to the type of graphic symbols that are commercially available and none of them employed any of these during their observed lesson. This is important as it demonstrates that teachers are not familiar with this type of symbols

or with the specific terminology with regards to them. This conclusion was also confirmed during the lesson observation, since teachers used pictures, photographs and drawings but not any graphic symbols. This is discussed below. These findings also align with other research conducted in the Cypriot context on the understanding regarding graphics symbols (Pampoulou & Angelides, 2012; Pampoulou, 2015).

Teachers' use of graphic symbols

As it has already been reported, the results indicate that the teachers believed that symbols are important because they can be used to: a) save time during lessons, b) support children's development and understanding and c) enable communication between teacher and child. The results show that the teachers did not use graphic symbols with linguistic characteristics during their teaching, despite the evidence presented in section 1 that these symbols can be used to convey science concepts to young children and help with their language development (such as with the word 'energy' in that the meaning changes when it is used when teaching a science lesson). In this section the focus is on the participants' use of symbols in general.

The teachers reported that they used different types of symbols, such as pictures, drawings and/or photographs to create their own materials for science lessons. Specifically, teacher 1 was observed using a picture to explain to children the experiment that she was about to demonstrate. At interview, she commented that science is 'a universal language and that all children, despite their cultural, religious or language differences, can understand and remember things that they see happening in front of their eyes. Using symbols to support what you are explaining can be very useful because you can then take those graphic symbols and put them on the wall somewhere and children will remember that activity or lesson every time that they see that on the wall'.

This teacher reported that she used graphic symbols during her lesson when she provided 'a graphical representation to symbolise and explain the experiment procedure' (Figure 3). What the teacher was observed doing though, was presenting a picture to symbolise the different items used for the experiment so as to add a visual reference to supplement the verbal explanation she gave about what was to be done. Consequently, this did not include any use of graphic symbols to facilitate communication or to support the children's understanding.

Teacher 6 also reported that she employed symbols during her lesson which was developed around a story. The pictures shown above were used during the teacher's delivery (see Figure 4) when she engaged the children by asking them to use arrows to show the series of events (and their direction of action) occurring during the water cycle (one child at a time). She stated that this method can help children

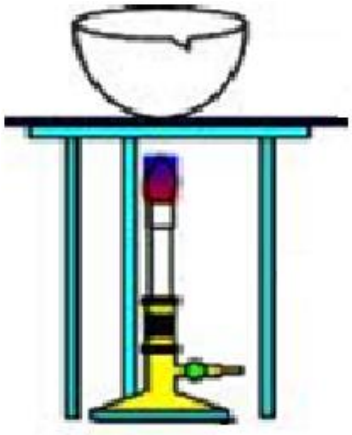

Figure 3. The picture used by Teacher 1, in lesson 1, to explain the experiment procedure to the children

understand relationships between events and that 'Arrows or similar symbols can help children to understand what comes after what in a series of events. I also like using graphic symbols [term used here refers to picture(s) and not to commercially available graphic symbols] and at the same time provide the words underneath to help children remember and also make connections with letters that we are learning like e.g. S for sun or W for water'. As the teachers explained, most children could not read but some were able to recognise and also read some letters, which helped them 'guess' the rest of the word. The same teachers added that using a picture to symbolise the word also helped the children to express their ideas and remember difficult words, such as evaporation. However, it should be noted that this particular teacher was one of those who reported that she used graphic symbols, when in reality this was not the case.

Teacher 4 was another teacher who claimed that she used graphic symbols during her teaching, whereby she developed a worksheet to replace words aimed at summarising the series of events occurring during the water cycle for evaluating children's understanding. As shown in the pictures (See Figure 5), the teacher was observed replacing words like sun, sea, evaporation and clouds. She was also observed using arrows pointing upwards to symbolise graphically the concepts of evaporation, but she was not observed using any graphic symbols containing linguistic characteristics.

Another significant outcome that resulted from the interviews, and was strongly supported by data from teacher 4, referred to the teacher's unease regarding the effectiveness of symbols she had created on her own. As she put it, 'I am not sure if using this worksheet was very helpful for the children. I saw some children drawing red and green clouds and when I asked them why they chose that colour they just

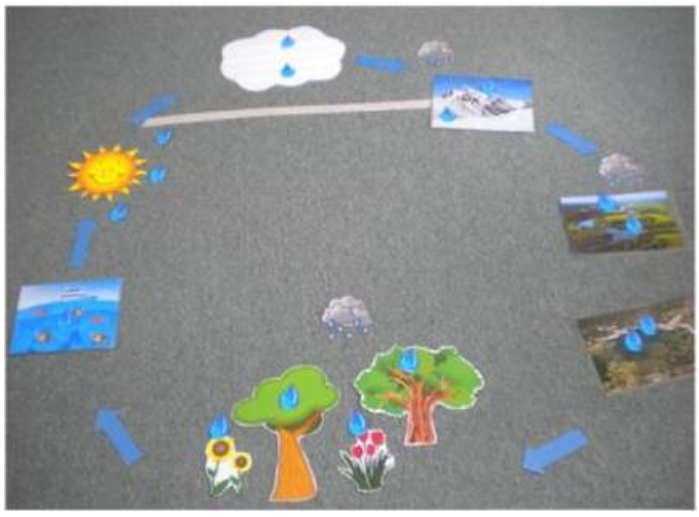

Figure 4. The Water Cycle with pictures 'on the floor' from Teacher 6, lesson 6

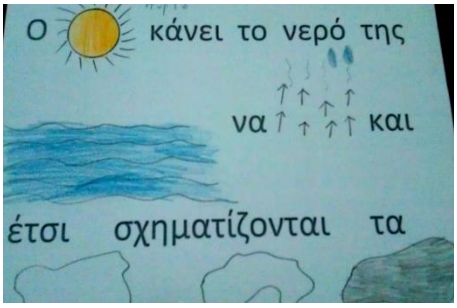

Figure 5. Examples of children's completed worksheets from Teacher 4, lesson's 4 final activity

said "Because I like it"'. This quotation illustrates that sometimes clarifying what children really know can be very difficult, hence, it not always easy for teachers to choose appropriate methods when explaining or assessing understanding. It could be perhaps argued that this teacher could create diagrams with graphic symbols (as mentioned above, the symbol software Symwriter is already available in all schools), download them and then share them with their colleagues, thereby saving time. Also, if they standardised the teaching process, it would easier to assess whether the examples work in the light of experience and if not, modify them, which would be quite simple to do. Teachers 1 and 6 also pointed out that using symbols is very time consuming for them, because they themselves have to create them and so it was not something they would do frequently. The above clearly shows that these teachers were not familiar with the commercially available graphic symbols and hence, they created their own.

CONCLUSIONS AND IMPLICATIONS

The encouraging outcome deriving from this study is that the teachers acknowledged the benefit of using symbols in that they expressed the belief that they could support children's understanding and conceptual development during lessons. Based on the comments made during the interviews, it seems that early years teachers do use symbols to enable communication with children in support of their comprehension and vocabulary use. They also believe that the use of symbols can encourage children to follow instructions, communicate and ask questions. In general, they acknowledged that the use of some types of symbols can provide equal access to learning, thereby improving children's participation. In fact, all the participants stated that they would use symbols to support their teaching.

The results also suggest that teachers are not familiar with graphic symbols as only half of the sample recognised the term and none were able to provide an appropriate example of a graphic symbol. The three teachers who claimed that they did so were actually using pictures and photographs. The teachers pointed out that using symbols can be very time consuming as they believed that they were the people who had to create them. This implies that none of them was aware of commercially available graphic symbols or software, such as the SymWriter symbols software introduced by the MoEC (2008b), which was surprising. That is, none of them knew about the possibility of creating symbolised teaching/learning resources (for example for the lesson on the Water Cycle), which they could then share with other colleagues. This would suggest that the use of graphic symbols in Cyprus is largely, if not entirely, restricted to special education contexts, such as special schools and special units located in mainstream schools (Pampoulou, 2015).

The above indicates a strong need to inform teachers of the commercially available graphic symbols and software. It also highlights a potential need for training in how to employ graphic symbols in ways that will save them time and yet, still support children's understanding and development in an effective way (Charalampous, 2012; Danos, 2014). As previously demonstrated, these results are of great importance for science education since supporting language and communication can enable children, from different countries, cultures, educational systems and languages, to learn science. Further research is necessary in order to investigate this issue in greater depth and with bigger samples, especially since the findings suggest that there is a need for additional teacher training through pre-service and in-service professional development courses.

ACKNOWLEDGMENTS

We would like to take this opportunity to express our gratitude to our mentors and colleagues for their constant support and useful comments. We would also like to thank Widgit Symbols Software 2002-2015 for giving us permission to use some of their materials as examples in this paper. Finally, we would like to thank the Ministry of Education and Culture in Cyprus for sharing useful information and documents with us and for providing the permission to conduct this study in Cypriot mainstream schools.

REFERENCES

Abbott, C. (2000). *Symbols Now*. Leamington Spa: Widgit Software.

Abbott, C., & Lucey, H. (2005). Symbol Communication in Special Schools in England: The Current Position and Some Key Issues. *British Journal of Special Education,* 32(4), 196-201.

Abbott, C., Detheridge, T., & Detheridge, C. (2006). *Symbols, Literacy and Social Justice.* Leamington: Widgit.

Acha, J. (2009). The Effectiveness of Multimedia Programmes in Children's Vocabulary Learning. *British Journal of Educational Technology,* 40, 23–31.

Allen, M. (2014). *Misconceptions in Primary Science*. (2nd ed.). Maidenhead: Open University Press.

Armstrong, F. (2003). *Inclusive Education: Cross-Cultural Perspectives*, *Spaced Out: Policy, Difference and the Challenge of Inclusive Education*. Kluwer Academic Publishers

Armstrong, D., Armstrong, A.C., & Spandagou, I. (2011). Inclusion: by choice or by chance?. *International Journal of Inclusive Education,* 15(1), 29-39.

Baskerville, R. L., Kaul, M., & Storey, V. C. (2015). Genres of inquiry in design-science research: Justification and evaluation of knowledge production. *Mis Quarterly*, 39(3), 541-564.

Baumgartner, A. A. (2015). *Instruction to augmentative alternative communication (AAC) users in the home and community environment* (Doctoral dissertation, California State University, Sacramento).

Bazeley, P., & Jackson, K. (2013). *Qualitative Data Analysis with NVivo*. Sage Publications

Beukelman, D.R. & Mirenda, P. (2013). *Augmentative and Alternative Communication: Supporting children and adults with complex communication needs*. (4th ed.). Baltimore: Paul H. Brookes Publishing Co.

British Educational Research Association (BERA). (2011). *Ethical Guidelines for Educational Research.* Retrieved from http://www.bera.ac.uk/wp-content/uploads/2014/02/BERA-Ethical-Guidelines-2011.pdf.

Bondy, A. S., & Frost, L.A. (1994). The Picture Exchange Communication System. *Focus on Autism and Other Developmental Disabilities* 9(3), 1-19.

Callaghan, T. (2000). Factors Affecting Children's Graphic Symbol Use in the Third Year: Language, Similarity and Iconicity. *Cognitive Development* 15, 185-214

Charalampous, E. (2012). The Use of Graphic Symbols to Improve the Skill of Questioning at the Age of 3.5 to 5 Years Old. *12th Conference of Cyprus Pedagogical Association* – Conference Proceedings. Retrieved from http://www.pek.org.cy/Proceedings_2012/papers/nipiosxoliki/Charalambous.pdf

Chetwynd, J. (2008). Communication with Symbols: From the Web to the Internet and Beyond. *Journal of Assistive Technologies,* 2(3), 32-36.

Cohen, M., & Kagan, M. (1979). Where does the old moon go? *Science Teacher,* 46(8), 22-23.

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing Scientific Knowledge in the Classroom. *American Educational Research Association*, 23(7), 5-12.

Crosskey, L., & Vance, M. (2011). Training teachers to support pupils' listening in class: An evaluation using pupil questionnaires. *Child Language Teaching and Therapy*, 27, 165-182.

Danos, X. (2014). Graphicacy and Culture: Refocusing on Visual Learning. Great Britain: Loughborough Design Press

de Villiers, M. R. (2005). *Three approaches as pillars for interpretive Information Systems research: development research, action research and grounded theory.* Proceedings of the 2005 annual research conference of the South African institute of computer scientists and information technologists on IT research in developing countries. 142-151.

EECERA. (2014). *EECERA Ethical Code for Early Childhood Researchers.* Version 1.0. Retrieved from www.eecera.org

Fragkiadaki, G., & Ravanis, K. (2015). Preschool children's mental representations of clouds. *Journal of Baltic Science Education*, 14(2), 267-274.

Fristoe, M., & Lloyd, L. L. (1979). Nonspeech Communication. In N. R. Ellis (Eds.), *Handbook of mental deficiency: Psychological theory and research.* New York: Lawrence Erlbaum Associates.

Fuller, D. R., Lloyd L. L., & Schlosser, R. W. (1992). Further Development of an Augmentative and Alternative Communication Symbol Taxonomy. *Augmentative and Alternative Communication*, 8(1), 67- 74.

Gerring, J. (2007). *Case Study Research: Principles and Practises*. Cambridge: University Press.

Gillon, R. (1986). Philosophical Medical-Ethics. *British Medical Journal,* 292, 48 - 49.

Glennen, S., & DeCoste, D. C. (1997). *The Handbook of Augmentative and Alternative Communication*. San Diego: Singular Pub. Group.

Gomez-Arizaga, M. P., Bahar, A. K., Maker, C. J., Zimmerman, R., & Pease, R. (2015). How Does Science Learning Occur in the Classroom? Students' Perceptions of Science Instruction During the Implementation of REAPS Model. *Eurasia Journal of Mathematics, Science & Technology Education*, 12(3), 431-455.

Greenstock, L., & Pampoulou, E. (2010). An introduction to two pieces of recent research in the use of graphic symbols. *Journal of Communication Matters*, 24(2), 32-35.

Greenstock, .L., & Wright, J. (2011). Collaborative Implementation: Working Together when Using Graphic Symbols. *Child Language Teaching and Therapy, 27(3),* 331-343.

Hall, R. (2008). *Applied social research: Planning, designing and conducting real-world research*. Macmillan Education AU.

Hanuscin, D. (2001). *Misconceptions in Science.* Web-based resource for teachers. Retrieved From: http://www.indiana.edu/~w505a/studwork/deborah/

John, P. S. & Vance, M. (2014). Evaluation of a principled approach to vocabulary learning in mainstream classes. *Child Language Teaching and Therapy*, 30, 255-271.

Johnston, J. (2005). *Early Explorations in Science.* (2nd ed.). Maidenhead: Open University Press.

Kambouri, M. (2015). Investigating Early Years Teachers' Understanding and Response to Children's Preconceptions. *European Early Childhood Education Research Journal.* 25 (3), DOI: 10.1080/1350293X.2014.970857

Kapalkova, S., Polisenska, K. & Sussova, M. (2015). The role of pictures and gestures as a support mechanism for novel word learning: A training study with 2-year-old children. *Child Language Teaching and Therapy*.

Kersner, M. & Wright, J. A. (2012). *Speech and language therapy: The decision-making process when working with children.* Routledge: Taylor Francis Group.

Kim, J-I., & Yoon, H.-G. (2016). Preservice Elementary Teachers' Beliefs about Nature of Science and Constructivist Teaching in the Content-specific Context. *Eurasia Journal of Mathematics, Science & Technology Education*, 12(3), 457-475.

Klein, H., & Myers, M. (1999). A Set of Principals for Conducting and Evaluating Interpretive Field Studies in Information Systems. *MIS Quarterly*. 23(1), 67-94.

Lacey, P., Layton, L., Miller, C., Goldbart, J., & Lawson, H. (2007). What is Literacy for Students with Severe Learning Difficulties? Exploring Conventional and Inclusive Literacy. *Journal of Research in Special Educational Needs,* 7, 149-160.

Leedy, P. D. & Ormrod, J. E. (2001). *Practical Research: Planning and Design*. Upper Saddle River, NJ: Merrill Prentice Hall.

Lloyd, L.L. & Blischak, D.M. (1992). AAC Terminology Policy and Issues Update. *Augmentative and Alternative Communication,* 8(2), 104-109.

Lloyd, L. L., Fuller, D. R. & Arvidson, H. (1997). (Eds.). Augmentative and alternative communication: A handbook of principles and practices. Boston, MA: Allyn and Bacon.

Lloyd, L.L. (1985). Comments on terminology. *Augmentative and Alternative Communication,* 1(3), 95-97.

Loizou, E. & Papademetri-Kachrimani, C. (2011). *Curriculum for Pre-School Education* (original in Greek). Cyprus: Ministry of Education.

Mavrou, K. (2011). Assistive Technology as an Emerging Policy and Practice: Processes, Challenges and Future Directions. *Technology and Disability*, 23(1), 41-52.

Mavrou, K., Charalampous, E., & Michaelides, M. (2013). Graphic symbols for all: using symbols in developing the ability of questioning in young children. *Journal of Assistive Technologies,* 7(1), 22-33.

Mayer, R. E. (1997). Multimedia Learning: Are we Asking the Right Questions? *Educational Psychology,* 32, 1–19.

McArthur, T. (1992). Sign. *The Oxford Companion to the English Language*. Oxford: Oxford University Press.

Ministry of Education and Culture (MoEC). (2008a). *Inclusion in the Cyprus Educational System at the Beginning of the Twenty First Century: An Overview.* National Report of Cyprus. Nicosia

Ministry of Education and Culture (MoEC). (2008b). *Educational Software Secured by ΑΔ 05/08 for Primary Education.* Retrieved from www.e-epimorfosi.ac.cy/userfiles/ep0508_dimotiki.

Ministry of Education and Culture (MoEC). (2009). *Funding for Kindergartens, Primary Schools and Special Education Schools to Equip Special Needs and Speech Therapy Rooms with Educational Material and Software for Children with Special Needs*. Retrieved from http://egkyklioi.moec.gov.cy/Data/dde2172a.pdf

Ministry of Education and Culture (MoEC). 2012*. Instruction Manual for Sym Writer*. Retrieved from http://www.schools.ac.cy/klimakio/logismika/pdf_logismika/symvolografos/symvolografos_odigos_chrisis.pdf

Ministry of Education and Culture (MoEC). (2014). *Official Website.* Retrieved from http://www.moec.gov.cy/dde/index.html

Mirenda, P. (2003). "He's Not Really a Reader [horizontal ellipsis]": Perspectives on Supporting Literacy Development in Individuals with Autism. *Topics in Language Disorders,* 23(4), 271-282.

Murcia, K. (2012). Integrating digital technologies into the contemporary science classroom. In D. Tan, M. Kim, & S. W. Hwang (Eds), *Moving forward: Issues and challenges in science education research* (pp. 225-244). Dordrecht, Heidelberg New York, London: Springer.

Murcia, K. (2014). Interactive and multimodal pedagogy: A case study of how teachers and students use interactive whiteboard technology in primary science. *Australian Journal of Education*, 58, 74-88.

Ntalakoura, V., & Ravanis, K. (2014). Changing preschool children's representations of light: a scratch based teaching approach. *Journal of Baltic Science Education*, 13 (2), 191-200.

Pampoulou, E., & Abbott, C. (2013). *Visual Timetables*. Communication Matters, 27(2), 35-38.

Pampoulou, S. E., & Angelides P. (2012). *The Use of Graphic Symbols in Promoting Inclusion in Two Mainstream Primary Schools in Cyprus*. (conference proceedings) 8th Panhellenic Conference on Education: Greece.

Pampoulou, E., & Detheridge, C. (2007). The Role of Symbols in the Mainstream to Access Literacy. *Journal of Assistive Technologie*s, 1(1), 15-21.

Pampoulou, S. E. (2013). *Using Graphic Symbols to Promote Inclusive Education* (presentation), 15th Biennial EARLI Conference: Germany.

Pampoulou, E. (2015). *The use of graphic symbols in inclusive primary schools: an exploration of teachers' and speech and language therapists' experiences of graphic symbols* (Unpublished thesis). King's College London

Philippou, S., Papademetri-Kachrimani, C., & Louca, L. (2015). The exchange of ideas was mutual, I have to say': Negotiating researcher and teacher 'roles' in an early years educators' professional development programme on inquiry-based mathematics and science learning. *Professional Development in Education*, 41(2), 382–400, doi.org/10.1080/19415257.2014.999381

Phtiaka, H. (2007). Educating the Other: A Journey in Cyprus Time and Space, in Barton, L. & Armstrong, F. (Eds.). *Policy, Experience and Change, Cross Cultural reflections on Inclusive Education,* London: Springer Books.

Pieridou, M. (2013). *Special and Inclusive Education in Cyprus: Case Study of a School Unit with regards to the Implementation of the 113(I)/99 Law in Educational Practice*, PhD Thesis, University of Cyprus.

Rankin, J. L., Harwood, K., & Mirenda, P. (1994). Influence of Graphic Symbol Use on Reading Comprehension. *Augmentative and Alternative Communication,* 10, 269–281.

Russell, T., & Watt, D. (1992). *Primary Space Project Research Report. Evaporation and Condensation*. Liverpool: University Press.

Sheehy, K., Rix, J., Fletcher-Campbell, F., Crisp, M. & Harper, A. (2013). Conceptualising inclusive pedagogies: Evidence from international research and the challenge of autistic spectrum disorder. *Erdelyi Pszichologiai Szemle* (Transylvanian Journal of Psychology, XIV(1).

Silverman, D. (2000). *Doing Qualitative Research: A Practical Handbook*. London: Sage Publications.

Simpson, M., & Tuson, M. (2003). *Using Observations in Small-scale Research: A Beginner's Guide.* Glasgow: Scottish Council for Research in Education.

Song, Y., & Carheden, S. (2014). Dual meaning vocabulary (DMV) words in learning chemistry. *Chemistry Education Research and Practice*, 15(2), 128-141.

Symeonidou, S. & Phtiaka, H., (2012). My colleagues wear blinkers... If they were trained, they would understand better'. Reflections on teacher education on inclusion in Cyprus. *Journal of Research in Special Educational Needs,* doi: 10.1111/j.1471-3802.2012.01234.x

UNESCO. (1994). *The Salamanca Statements and Framework for Action on Special Needs Education,* Paris: UNESCO.

UNESCO. (2009). Policy Guidelines on Inclusion in Education. Paris: UNESCO. Retrieved from http://unesdoc.unesco.org/images/0017/001778/177849e.pdf.

Venkatagiri H. S. (2002). Clinical Implications of an Augmentative and Alternative Communication Taxonomy. *Augmentative and Alternative Communication,* 18(1), 1-24.

Vislie, L. (2003). From Integration to Inclusion: Focusing Global Trends and Changes in the Western European Societies. *European Journal of Special Needs Education,* 18 (1), 17-35.

Vrasidas, C., & Glass, G. V. (2006). (Editors). *Current Perspectives on Applied Information Technologies: Preparing Teachers to Teach with Technology*. Greenwich, CT: Information Age Publishing.

Walsham, G., (1995). Interpretive Case Studies in IS Research: Nature and Method. *European Journal of Information Systems*, 4(2), 74-81.

Wellington, W., & Wellington, J. (2002). Children with Communication Difficulties in Mainstream Science Classrooms. *School Science Review,* 83(305), 81-92.

Wellington, W. & Stackhouse, J. (2011). Using visual support for language and learning in children with SLCN: A training programme for teachers and teaching assistants. *Child Language Teaching and Therapy*, 27, 183-201.

Widgit Symbols. (2002-2015). *Widgit Software (c).* Retrieved from www.widgit.com

Wragg, E. C. (1994). *An Introduction to Classroom Observation.* London: RoutledgeFalmer.

Young, E. (2005). The Language of Science, the Language of Students: Bridging the Gap with Engaged Learning Vocabulary Strategies. *Science Activities: Classroom Projects and Curriculum Ideas,*42(2), 12-17.

◈⊙◈